EFFICACY OF STRYCHNINE EGGS FOR CONTROLLING FRANKLIN GROUND SQUIRRELS

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In February 1985, the Environmental Protection Agency (EPA) established standards for reregistering strychnine for controlling ground squirrels. One standard required efficacy data on strychnine concentrations below those presently registered with the EPA. The 8.0 mg of strychnine per treated egg currently registered in North Dakota (ND820001) for controlling Franklin ground squirrels (*Spermophilus franklinii*) on waterfowl production areas (WPA's) was included in this standard.

The U.S. Fish and Wildlife Service (USFWS) decided to maintain the strychnine egg registration because this is the only method available for controlling this species on WPA's. In 1986, the Denver Wildlife Research Center (DWRC) conducted laboratory tests indicating that no ground squirrel mortality occurred after they fed on 0.5 mg, 1.0 mg, or 2.0 mg strychnine-treated eggs. Ground squirrel mortality was 88%, 89%, and 88% after feeding on 3.0 mg, 4.0 mg, and 5.0 mg strychnine eggs, respectively. All died after feeding on 6.0 mg strychnine eggs (Matschke, unpublished data).

In 1987, the USFWS funded a field study to compare the efficacy of lower concentrations (4.0 mg and 6.0 mg) with the standard 8.0 mg strychnine-treated egg. The objective of the study protocol was to measure mortality among free ranging Franklin ground squirrels that were equipped with radio transmitters, and exposed to the strychnine-treated eggs. However, poor consumption and low mortality precluded any meaningful data. Therefore, the study protocol was modified so that strychnine-treated egg consumption and subsequent mortality could be evaluated with captured

ground squirrels. The results of both methods are presented in this report.

METHODS

Study Area

USFWS's 20 WPA's were selected for this study. These were located near Woodworth, Stutsman County, North Dakota. Each area had a population of Franklin ground squirrels.

Experimental Design

Each of the strychnine treatments (0.0 mg, 4.0 mg, 6.0 mg, and 8.0 mg) was randomly assigned to 5 of the 20 WPA's. The 20 WPA's were then grouped into 5 blocks, with each block containing 1 WPA from each of the 4 strychnine concentrations.

Preparation of Strychnine Solutions

The strychnine solutions were prepared with the 5 ingredients listed in the Confidential Statement of Formula for registration ND-820001. Because the technical strychnine alkaloid (CAS# 57-24-9) assayed at 98% purity, the quantity of strychnine to be used in each concentration was calculated as follows:

$$\text{amount of strychnine required} = \frac{\text{desired concentration} \times \text{size of batch}}{\text{purity of strychnine alkaloid}}$$

Microtaggants could not be stirred into the strychnine solutions because of their magnetic activity. Therefore, the microtaggants were added directly to each egg.

The amount of each solution prepared was enough to inject about 70 medium-size chicken eggs. Solutions were prepared by combining 2 drops each of red, blue, and green food dyes, honey, and distilled water. This solution was heated ("low" setting) and stirred for a minimum of 15 minutes. The measured strychnine was added and stirring continued for 15 more minutes. The control solution (0.0 mg) was prepared in the same way except that strychnine was omitted. The solutions were stored in a refrigerator.

The Analytical Chemistry Section at the DWRC verified the strychnine concentration of each solution by using Analytical Method 2A (Strychnine Alkaloid Technical, Formulation, and Bait Assay).

Egg Preparation

The strychnine solution was removed from the refrigerator and placed on a stirrer/hot plate (low speed/low heat) for 10 minutes. A hole (about 3 mm diameter) was drilled into the large end of each medium-size chicken egg. The yolk and albumen were blended together by inserting a bent nail (6 p) attached to a Dremel[2] drill into the hole. One gram of the egg contents was removed with a hypodermic syringe and an 8-gauge needle and this was replaced with approximately 0.01 g of microtaggants and 0.99 g of strychnine solution. The contents were blended together again and the hole was covered with a small piece of toilet tissue. The egg was momentarily inverted to adhere the tissue to the egg. When the tissue dried it was sealed with epoxy. The word "POISON," in red ink, was stamped 3 times on the egg, and the concentration and the ascending egg number were also written on each egg. It was weighed and attached to a 12.7 cm plywood square with hot glue. The control eggs were prepared as described above, but the word "CONTROL" was stamped 3 times on each. All eggs were prepared and refrigerated the day before placement.

Original Procedure for Placement of Eggs

Thirty-four squirrels were to be trapped on each block and fitted with a radio transmitter (Fagerstone et al. 1985). On each block, 10 animals were trapped on each of the 3 WPA's assigned to receive the strychnine eggs and 4 animals were trapped on the WPA assigned as the control plot. Each animal was weighed, sexed, eartagged with a unique number, and released at the capture site.

On the evening before egg placement, the burrow system of each radio-equipped squirrel was located and marked with a flag. The next morning (Day 1), before sunrise, 1 egg of the appropriate strychnine concentration was placed adjacent to the burrow entrance and anchored with 2 metal spikes. A movie camera (Minolta Super 8 XL601, Kodak Model # 147-2776 or Chinon Super 8 612XL MACRO) with an interval timer, exposed 1 new frame every 15 seconds. The first frames recorded data on a card including site number, date, egg number, concentration, and animal number. After egg placement, human activity ceased on each WPA until mid-day.

At mid-day (Day 1), the eggs were examined. If the first egg was consumed the egg remnants were removed and weighed. The radio-equipped ground squirrel assigned to that egg was radio-tracked. If located dead on the surface, the carcass was collected and frozen for strychnine residue analysis; if located underground, the location was marked with a flag. Unconsumed or partially consumed eggs were checked again on Day 1, after the squirrels went underground for the night. The mid-day procedure was followed if an egg was consumed. The position of squirrels that consumed eggs at mid-day was determined. Cameras and all uneaten eggs were removed and film was mailed for processing.

The next morning (Day 2), before sunrise, all radio-equipped squirrels that were offered eggs on Day 1 were located and the positions marked. A second egg of the same strychnine concentration was offered to squirrels that had consumed an egg by mid-day on Day 1 but were not recovered, animals which did not consume an egg on Day 1, and those animals that consumed an egg in the afternoon on Day 1. These second eggs were placed either at the original site or at another burrow entrance thought to be used by the same animal. The camera was positioned as before. After all the eggs were placed, human activity ceased on the WPA until mid-day when the procedures for Day 1 were repeated. Ground squirrels not showing movement were presumed dead underground and were excavated. If required, a third egg was placed the next morning (Day 3) following the procedure described for Day 2.

On the next morning (Day 4), testing ceased. All radio-equipped squirrels were located, their positions were marked and animals presumed dead were excavated. Recovered carcasses were frozen for subsequent strychnine residue analysis.

By reviewing the films, we identified radio-equipped ground squirrels that consumed eggs and those that refused eggs. We also identified and recorded Franklin squirrels without transmitters and 13-lined ground squirrels (*Spermophilus tridecemlineatus*) that consumed eggs.

Revised Egg Preparation Procedures

As the study progressed, changes became necessary in the preparation of eggs; these were as follows:

Hot glue replaced epoxy because small amounts of the egg contents occasionally seeped from the hole. The hole was drilled

in the side of the egg rather than the end, and expanded to approximately 10 mm. This hole was covered with toilet tissue as before, but the tissue was moistened with a drop of the blended egg contents extracted before the strychnine was added. This eliminated the need to invert the egg and ensured a better seal. The egg was hot glued to the wood square with the covered hole up. The amount of blended egg contents removed from the egg was increased from 1.0 to 1.5 g. This was necessary because the hole drilled in the side of the egg resulted in increased foaming of the contents and reduction of available head space, causing spillage. Later the amount of blended egg contents removed was increased from 1.5 to 2.0 g. The eggs were no longer refrigerated after preparation, as increased early morning temperatures and humidity caused water vapor to condense on the eggs when they were removed from the refrigerator, smearing the red ink markings and occasionally loosening the eggs from the boards.

Modified Procedure for Placement of Eggs

The original objective given in the protocol could not be achieved on schedule with the available funds because of the: 1) low numbers of ground squirrels trapped on the WPA's, and 2) low mortality of radio-equipped ground squirrels after strychnine egg treatment.

Therefore, the study protocol was modified so that the treated eggs could be evaluated with trapped squirrels. Traps on each WPA were opened and baited in the morning, examined at mid-day, and closed before dark. Each trapped animal was given a small rather than medium-sized chicken egg with the appropriate strychnine concentration. The traps were sheltered against the weather. The egg was glued to a board and anchored to the ground. All eggs were checked each evening and the following morning. Dead animals were removed, weighed, sexed, and frozen for residue analysis. The egg remnants were removed and weighed. Ground squirrels alive 24 hours after egg placement were ear-tagged, weighed, sexed, equipped with a radio-transmitter, and released. They were tracked for 3 days post-treatment (Treatment day = Day 1). An animal that did not consume an egg was ear-tagged, weighed, sexed, equipped with a radio-transmitter, and released to determine its fate post-treatment. Each squirrel was tracked for 3-days post-treatment (Treatment day = Day 1). In recording the number of days-to-death, the first day of treatment was counted as Day 1.

A total of 22, 38, 56, and 57 ground squirrels was tested on each of the 4 strychnine concentrations (0.0, 4.0, 6.0, and 8.0 mg, respectively).

Statistical Analysis

Mortality data were analyzed by Chi-square tests; an overall 2 x 3 table and 3 2 x 2 tables were used to compare the 3 treatments by pairs.

Differences in egg consumption and mg of strychnine per kg of body weight (mg/kg) among the 3 strychnine concentrations and the control concentration were analyzed by an unbalanced 2-factor analysis of variance. When main effects were found to be significant ($P < 0.05$) individual means were compared using Duncan's multiple range test. The 2-way lay outs were as follows:

Source	Consumption d.f.	mg/kg d.f.
Treatment (T)	3	2
Sex (S)	1	1
T x S	3	2
Error	127	108
Total	134	113

Strychnine Residue Analysis

Dead radio-equipped or non-radio-equipped Franklin ground squirrels and dead nontarget wildlife found on the study areas were collected and frozen for strychnine residue analyses. The United States Department of Agriculture (USDA) laboratory at Gulfport, Mississippi analyzed the tissue by using high pressure liquid chromatography methods. Stomach, liver, and muscle tissues were analyzed for strychnine residues. A black-light revealed microtaggants. Means and standard errors for the strychnine residues were calculated for each tissue type.

RESULTS

Original Procedure for Placement of Eggs

Of 62 radio-equipped Franklin ground squirrels only 24 (37%) fed on the eggs, 14 (61%) died, and 10 (39%) survived. The small number of animals that consumed eggs plus the number of eggs shared with other animals precluded valid statistical analysis to determine differences in mortality or mg/kg intake of strychnine among the 3 treatments. The percentage of eggs ingested, total mg/kg intake of strychnine, and fate of Franklin ground squirrels among the control and 3 strychnine concentration groups are summarized as follows:

0.0 mg strychnine (control): Only 1 of 4 animals consumed an egg. Animal #566 consumed 9.01 g of egg material, or 23.78% of the egg contents (Table 1 on following page). Two ground squirrels (#133 and #573) were offered 3 eggs each; but both animals approached only the third egg. A fourth animal (#209) was offered only 1 egg, but the egg was ignored.

4.0 mg strychnine: Three (37.5%) of the 8 ground squirrels that fed on eggs died. One animal (#563) that died consumed 77.38% of the egg contents, with a strychnine intake of 3.02 mg or 7.74 mg/kg (Table 1). Twoother animals (#534 and #562) that died each shared their eggs with other ground 8squirrels. Therefore, no measurements on consumption and strychnine intake were possible. Five animals survived after feeding on the eggs (Table 1). Four of 5 survivors consumed an average of 58.86% of the egg's contents, with an average strychnine intake of 2.36 mg or 5.48 mg/kg. The fifth survivor (#529) consumed 100% of all 3 eggs, ingesting a total of 110.47 g of egg and 11.70 mg of strychnine, or 29.49 mg/kg. Eight ground squirrels did not eat eggs, although they were offered 3 eggs each. Of the 24 eggs placed for these 8 animals, non-radioed Franklin ground squirrels fed on 3 eggs.

6.0 mg strychnine: Six (85.7%) of the 7 ground squirrels that fed on eggs died. Three animals (#163, #360, and #375) that died consumed an average of 63.60% of the egg contents, with a mean strychnine intake of 4.36 mg or 11.75 mg/kg (Table 1).

Because animals #277, and #546 each shared their eggs with a *Microtus* spp. and another radio-equipped Franklin ground squirrel, respectively, no consumption or strychnineintake measurements were possible. The sixth animal (#535) consumed 54.95% of egg number 2 (3.90 mg of strychnine or 12.77 mg/kg), and consumed 94.87% of egg number 3 (6.74 mg of strychnine or 22.04 mg/kg) before dying (Table 1). One animal survived after feeding on an egg. This animal (#139) consumed 31.16 g of the egg contents with a strychnine intake of 5.18 mg or 14.13 mg/kg (Table 1). Fifteen ground squirrels were non-eaters after being offered 3 eggs each, and a sixteenth ground squirrel (#148) given only 1 egg was a non-eater. Of these 16 animals, only 1 (#168) visited an egg.

Table 1. Response of radio-equipped Franklin ground squirrels to eggs containing 0.0 mg, 4.0 mg, 6.0 mg, and 8.0 mg strychnine.

Plot No.	Strychnine concentration (mg)	Ear tag No.	Sex	Final body wt.(g)	Day egg was eaten	Amount consumed (g)	Percent consumed	Intake of strychnine (mg)	mg/kg	Remarks
56	0.0	566	M	387.6	3	9.01	23.78	-	-	Survived
16	4.0	563	M	390.2	1	28.70	77.38	3.02	7.74	Died Day 1 postrt
16	4.0	545	M	355.7	3	22.66	48.35	2.18	6.13	Survived
16	4.0	543	F	571.6	3	39.60	90.45	3.53	6.18	Survived
182	4.0	531	F	360.3	3	13.82	37.64	1.47	4.08	Survived
182	4.0	373	M	406.0	3	21.78	57.79	2.25	5.54	Survived
182	4.0	529	M	396.8	1	37.89	100.0	3.90	9.83	Survived
					2	36.43	100.0	3.90	9.83	Survived
					3	36.15	100.0	3.90	9.83	Survived
13E	6.0	375	M	355.2	1	31.50	71.04	5.04	14.19	Died Day 4 postrt
485	6.0	163	M	383.4	.2	14.29	37.96	2.24	5.84	Died Day 1 postrt
13E	6.0	360	F	382.0	3	35.01	81.80	5.81	15.21	Died Day 1 postrt
13E	6.0	535	F	305.4	2	25.15	54.95	3.90	12.77	Survived
					3	40.47	94.87	6.74	22.04	Died Day 2 postrt
13E	6.0	139	F	366.7	1	31.16	72.96	5.18	14.13	Survived
24	8.0	283	M	457.7	3	29.36	66.73	5.87	12.82	Died Day 2 postrt
57	8.0	281	M	388.0	3	22.10	49.00	4.64	11.96	Died Day 1 postrt
182A	8.0	559	M	548.3	1	35.15	100.0	8.60	15.38	Survived
24	8.0	590	F	358.2	2	28.61	71.60	5.73	16.00	Survived
						37.25	84.22	6.74	18.82	Survived

Of these 46 eggs placed for these 16 animals, non-radioed Franklin ground squirrels and 13-lined ground squirrels each fed on 2 eggs and a radioed Franklin ground squirrel (other than a target animal) fed on 1 egg.

8.0 mg strychnine: Five (62.5%) of the 8 ground squirrels that fed on eggs died. Two of these animals (#281 and #283) that died consumed an average of 57.86% of the egg contents, with a mean strychnine intake of 5.25 mg or 12.39 mg/kg (Table 1). Because 3 animals (#205, #555, and #558) each shared their eggs with other ground squirrels, measurements on their egg consumption and strychnine intake were not possible. Three animals survived after feeding on the eggs. One animal (#590) that survived fed on eggs 2 and 3. Its consumption of the 2 egg contents averaged 77.91%, with a total strychnine intake of 12.47 mg or 34.82 mg/kg (Table 1). The second survivor (#164) shared the third egg with other ground squirrels, measurements on its egg consumption and strychnine intake were not possible. The third survivor (#559) consumed 100% of the egg, with a strychnine intake of 8.60 mg or 15.38 mg/kg (Table 1). Eleven other ground squirrels did not eat eggs although they were offered 3 eggs each. Only 2 (18.1%) of these 11 animals visited the eggs, animal #276 visited the third egg and animal #511 visited the first and third eggs. Of the 33 eggs placed for these 11 animals, non-radioed Franklin ground squirrels fed on portions of 7 eggs and a 13-lined ground squirrel consumed a portion of 1 egg.

Modified Procedure for Placement of Eggs

The fate of 135 Franklin ground squirrels exposed to strychnine treated eggs was as follows: 114 (85%) died, 17 (13%) survived, 2 (1%) were non-feeders [male #248 (8.0 mg) and female #386 (4.0 mg)], and 2 (1%) were feeders, consuming 100% of the egg contents, but with an unknown fate. Animal #321 (6.0 mg) lost its radio transmitter and animal #235 (8.0 mg) escaped the trap; both animals were excluded from the statistics. Twenty-one control animals survived. Percentage of egg contents ingested, total mg/kg intake of strychnine, and fate of the animals among the control and 3 strychnine concentration groups are summarized below.

0.00 mg strychnine (control): Twenty-one animals (8 males, 13 females) fed on the control eggs and none (0.00%) died (Table 2). The twenty-second animal (#246), a male, did not feed during the 24-hour exposure period.

4.0 mg strychnine: Thirty animals (12 males, 18 females) fed on the 4.0 mg eggs and 23 (76.7%) died (Table 2). Death occurred on Days 1 (N=5), 2 (N=17), and 3 (N=1). Seven ground squirrels (2 males, 5 females) fed on the eggs and survived (Table 2).

6.0 mg strychnine: Fifty-two animals (19 males, 33 females) fed on the 6.0 mg eggs and 49 animals (94.2%) died (Table 2). Death occurred on Days 1 (N=12), 2 (N=36), and 3 (N=1). Three ground squirrels (1 male, 2 females) fed on the eggs and survived (Table 2).

8.0 mg strychnine: Forty-nine animals (20 males, 29 females) fed on the 8.0 mg eggs and 42 (85.7%) died (Table 2). Death occurred on Days 1 (N=14), 2 (N=26), and 3 (N=2). Seven ground squirrels (3 males, 4 females) fed on the eggs and survived (Table 2).

Table 2. Egg consumption, strychnine and mg/kg intake, and fate of Franklin ground squirrels given strychnine-treated eggs.

			Mean Percentage of eggs consumed		Mean strychnine intake		Mean mg/kg intake		
Concentration	Sex	N	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	Fate
0.0	M	8	100.0%		-		-		Survived
0.0	F	13	100.0%		-		-		Survived
4.0	M	10	94.94%	(2.52)	4.13mg	(0.14)	9.98	(0.61)	Died
4.0	F	13	88.14%	(4.69)	3.91mg	(0.21)	10.29	(0.77)	Died
4.0	M	2	100.0%		4.3mg	(0.20)	10.94	(1.06)	Survived
4.0	F	5	84.05%	(9.91)	3.58mg	(0.38)	11.41	(1.07)	Survived
6.0	M	18	97.09%	(2.09)	5.85mg	(0.15)	15.26	(0.50)	Died
6.0	F	31	88.73%	(2.83)	5.31mg	(0.18)	14.03	(0.56)	Died
6.0	M	1	100.0%		6.20mg		14.99		Survived
6.0	F	2	100.0%		6.05mg	(0.15)	14.98	(0.72)	Survived
8.0	M	17	88.33%	(5.16)	7.87mg	(0.44)	17.88	(0.96)	Died
8.0	F	25	74.67%	(4.74)	6.91mg	(0.39)	17.72	(1.31)	Died
8.0	M	3	53.12%	(24.12)	4.62mg	(2.16)	15.68	(8.10)	Survived
8.0	F	4	96.68%	(3.32)	8.02mg	(0.23)	22.69	(1.08)	Survived

Statistical Analysis

The overall Chi-square test was not significant but indicated a low probability of occurrence ($P = 0.07$). Mortality at the 4.0 mg concentration was significantly less ($P = 0.02$) than mortality at the 6.0 mg concentration. Comparisons of mortality between the 4.0 mg and 8.0 mg concentrations ($P = 0.33$), and the 6.0 mg and 8.0 mg concentrations ($P = 0.14$) were not different.

Egg consumption and mg/kg data for the animals that died were analyzed with strychnine Treatment levels (3) and Sex (2) as main factors. For consumption of the egg contents, both Treatment ($P = 0.0016$) and Sex ($P = 0.0148$) were significant. For Sex, the females consumed significantly less of the egg contents ($\bar{x}$ = 33.15 g) than the males ($\bar{x}$ = 37.18 g). For the mg of strychnine per kilogram of body weight variable (mg/kg) only Treatment ($P = 0.0001$) was significant.

The means for both consumption (Treatment effect) and mg/kg (Treatment effect) were separated by Duncan's multiple range test. Note that ground squirrels consumed significantly less of the 8.0 mg egg than did the ground squirrels feeding on the 0.0, 4.0, and 6.0 mg eggs (Table 3). Additionally, all 3 concentrations were different from each other (Table 4).

Strychnine Residue Analysis

All 52 (100%) of the animals that fed on strychnine treated eggs and died, showed strychnine residues in their carcasses. Results of the residue analyses and presence of microtaggant marker are shown in Table 5 (on the following page). For the 0.0 mg (control) group, all tissue samples were negative for strychnine residue. For the 4.0 mg strychnine group all 10 (100%) stomachs, 8 (89%) of 9 livers, and 2 (20%) of 10 muscle tissue contained residues. For the 6.0 mg group, all 22 (100%) stomachs, 18 (95%) of 19 livers, and 2 (9%) of 22 muscle tissue samples contained strychnine residue. And finally, for the 8.0 mg group, all 20 (100%) of the stomachs, all 16 (100%) livers, and none of 20 muscle tissue samples contained strychnine residue.

Table 3. Mean egg consumption (g) by Fanklin ground squirrels eating strychnine-treated eggs.

Treatment (mg)	n	g	Letter[a]
0.0	21	37.70	a
4.0	30	36.85	a
6.0	52	36.69	a
8.0	49	30.88	b

[a]Means having no letter in common are significantly different ($P = 0.0016$).

Table 4. Mean dose rate (mg strychnine/kg body weight) of Fanklin ground squirrels eating strychnine-treated eggs.

Treatment (mg)	n	g	Letter[a]
4.0	30	10.42	a
6.0	52	14.43	b
8.0	49	14.43	c

[a]Means having no letter in common are significantly different ($P = 0.001$).

Table 5. Strychnine residue levels in stomach, liver, and muscle tissue obtained from Franklin ground squirrels given strychnine-treated eggs. Also the percentage of stomachs containing microtaggants are reported.

Concentration (mg/egg)	Percentage of stomachs with microtaggants (No. of stomachs sampled)	Strychnine Residue: Stomach n	$\bar{x}$	SE	Liver n	$\bar{x}$	SE	Muscles (No. of muscles) n	$\bar{x}$	SE
0.0	43% (7)	7	N.D.[a]		7	N.D.		7	N.D.	
4.0	70% (10)	10	1.93 mg	0.49	8	0.06 mg	0.0	2	0.01 mg	0.0
6.0	67% (18)	20[b]	1.27 mg	0.23	16[d]	0.14 mg	0.07	2	0.01 mg	0.008
8.0	71% (16)	19[c]	1.06 mg	0.20	16	0.07 mg	0.02	20	0.0 mg	0.0

[a]N.D. denotes strychnine was not detected.

[b]The stomachs of two additional animals (#160 and #576) contained strychnine residue, but failure to record stomach weights precluded calculating the quantity of strychnine.

[c]The stomachs of one additional animal (#345) contained strychnine residue, but failure to record the stomach weight precluded calculating the quantity of strychnine.

[d]The livers of two additional animals (#389 and #485) contained strychnine residue, but failure to record liver weights precluded calculating the quantity of strychnine.

DISCUSSION

The consumption and mortality data suggest that 4.0, 6.0, and 8.0 mg of strychnine in eggs was not enough to cause 100% mortality of Franklin ground squirrel populations. For example, 12 of 17 Franklin ground squirrels survived after feeding on 100% of the egg contents containing those concentrations. The percentage of strychnine in the 4.0, 6.0, and 8.0 mg levels in small eggs (mean egg weight 38 g) are 0.011%, 0.016%, and 0.021%, respectively. These concentrations are below the 0.20% strychnine in grain bait that killed 100% of 20 animals tested in the laboratory (Matschke et al. 1987). Therefore, for this species, the strychnine concentration needed for 100% mortality probably lies between the 0.021% and 0.20% levels. If this efficacy level is needed for controlling Franklin ground squirrels on WPA's, then concentrations exceeding 8.0 mg should be tested.

If a lesser degree of efficacy is acceptable, then the 8.0 mg egg could be replaced with the 6.0 mg treated egg without a loss of efficacy. Though not found to be statistically different, mortality at the 6.0 mg level actually exceeded the 8.0 mg level in both the field and trap phase of this study, and consumption levels at the 8.0 mg level were significantly lower then at the 6.0 mg level.

Our findings suggest that either improvements in the strychnine delivery system or alternative control methods need to be developed, since only 37% of the free-ranging, radio-equipped Franklin ground squirrels consumed strychnine-treated eggs under operational control conditions on WPA's.

The video films revealed that some Franklin ground squirrels experienced difficulty in penetrating the larger egg. Our data therefore, also suggest that medium-size eggs could be replaced with smaller eggs to

improve penetration and consumption of egg baits.

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